



Stockpile Stewardship at LLNL

Ensuring confidence in the safety, security, and effectiveness of the U.S. nuclear deterrent.

Experiments, Simulations, Theory Key to Confidence

Since 1992, scientists no longer confirm the performance of America's nuclear arsenal by conducting explosive tests underground at the Nevada Test Site. Instead, scientists ensure the continuing safety, security, and effectiveness of America's nuclear stockpile through the National Nuclear Security Administration's (NNSA's) science-based Stockpile Stewardship Program. Established in 1994, this program comprises surveillance, advanced simulations, scientific and engineering experiments, materials research, and refurbishment. As part of stockpile stewardship, LLNL scientists and engineers regularly assess the health of the stockpile to inform refurbishment decisions.

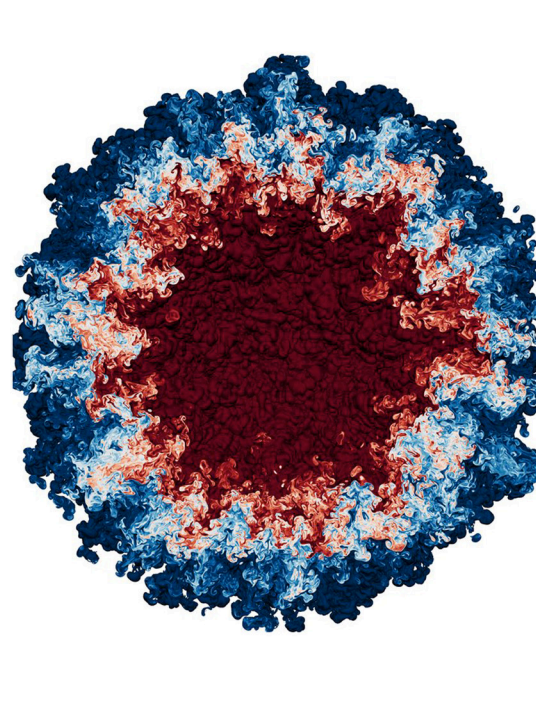
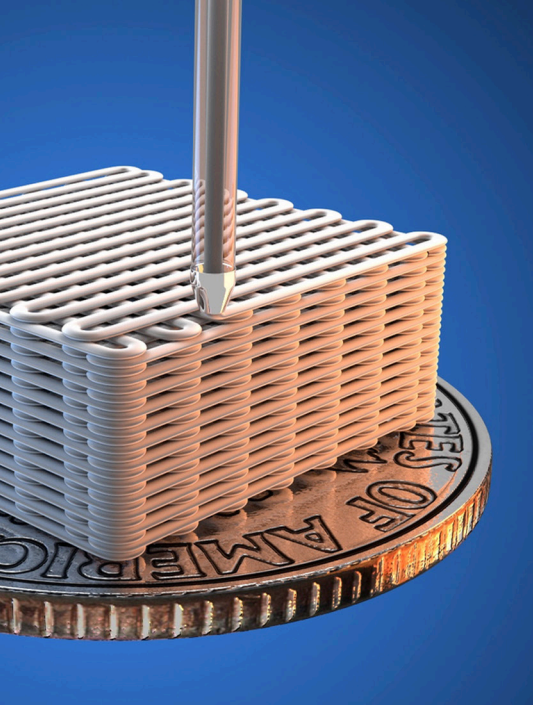
A critical part of stockpile stewardship is life extension programs (LEPs), which refurbish, replace, or redesign aging components of a warhead or bomb that require modernization. Experts design components and systems for the LEPs and certify the life-extended models when they enter the stockpile.

By ensuring confidence in the safety, security, and effectiveness of the U.S. nuclear deterrent, stockpile stewardship permits the nation to retain a small nuclear stockpile consistent with the need to deter adversaries and reassure allies.

Accomplishments

Despite stiff technical challenges, stockpile stewardship has worked exceedingly well, thanks to an expert workforce; advances in theory and understanding of how nuclear weapons work and the aging mechanisms that can degrade performance and safety; investments in world-class experimental facilities such as the National Ignition Facility (NIF) and the Contained Firing Facility (CFF); advances in materials and manufacturing; and development of new generations of supercomputers, including Sierra, the second-fastest computing system in the world. LLNL's many advances and accomplishments include these:

- In 2018 LLNL completed Cycle 23 of the annual stockpile assessment. As part of this extensive process, the nuclear design laboratories (Lawrence Livermore and Los Alamos) conduct peer reviews of each other's weapon systems.
- LLNL high-explosives experts have pioneered the use of insensitive high explosives (IHEs), which greatly lessens the possibility of accidental detonation.
- LLNL is making excellent progress in the LEP for the W80-4 warhead for the Air Force Long-Range Standoff missile. Livermore experts are working closely with the Air Force, the two competing contractors for building the missile, and researchers at several NNSA facilities.
- Recent upgrades to aging facilities and infrastructure at LLNL's main campus and remote Site 300 enhance support for stockpile stewardship.
- Multi-physics simulations performed on cutting-edge computer platforms have delivered powerful tools for design assessment and certification of nuclear weapon weapons and their components. The next-generation supercomputer, Sierra, is playing an important role in modeling complex physical phenomena.
- Experiments conducted on NIF, the world's largest and most energetic laser, make it possible to test materials in high-energy-density regimes formerly inaccessible to scientists.
- An LLNL team hunted down 6,500 decomposing films of the nation's 210 atmospheric nuclear tests. The films are scanned to preserve content and reanalyzed to extract more precise data about nuclear weapons performance.



Scientific Underpinnings

Stockpile stewardship takes advantage of five key LLNL core competencies: high-energy-density science, lasers and optical science and technology; advanced materials and manufacturing; high-performance computing (HPC) and simulation; and nuclear, chemical, and isotopic science and technology. For example, researchers studying the aging of weapons plutonium have combined advances in nuclear theory with new types of experiments and extremely large supercomputer simulations.

A critical element in stockpile stewardship is high-performance computing and simulation. LLNL's Sierra, with a peak speed of 125-petaflops (floating-point operations per second), is a six-fold performance improvement over LLNL's previously most capable supercomputer, Sequoia. Sierra performs complex multi-physics calculations needed for the demanding requirements of stockpile stewardship.

- The National Ignition Facility (NIF) supports stockpile stewardship through a wide range of experiments. Campaigns of high-energy-density science experiments on NIF explore environments central to stockpile stewardship and critical to understanding nuclear weapons performance.
- LLNL is taking advantage of revolutionary advanced manufacturing methods to make parts with optimized properties at lower costs and shorter production schedules.
- LLNL energetic materials scientists examine the physical, chemical, detonation, and mechanical properties of high explosives used in the nuclear stockpile. Researchers are working to enable the use of new insensitive-high-explosives to further enhance safety.
- Scientists are combining data from computer simulations, past nuclear tests, non-nuclear experiments, and theoretical studies to quantify confidence factors (known as quantification of margins and uncertainties) for assessing nuclear weapon performance without nuclear testing.
- In hydrodynamic testing at the Contained Firing Facility, components are subjected to extreme pressure and shock and start to behave like liquids. These experiments—combined with results from other experiments as well as theory and HPC—ensure confidence in the nation's nuclear deterrent by providing vital data about what happens during a nuclear detonation.
- Researchers have developed advanced diagnostic techniques that gather data to validate simulation models and enhance understanding of weapon physics.

The Future

During the next few years, researchers will be focused on meeting the goals of the W80-4 Life Extension Program (LEP) and the W87-1 modification. Livermore scientists and engineers will continue to explore ways to take advantage of advanced manufacturing to improve quality while reducing costs.

LLNL scientists will also continue to improve the physics and engineering simulation codes that support annual assessments as well as LEPs, with an emphasis on improving predictability and quantification of uncertainties. Stockpile surveillance activities, weapon subsystem tests, and flight tests will supply critical data to simulations.

Meeting Stockpile Stewardship Program goals demands outstanding scientific and engineering talent. In response to large numbers of retiring experienced researchers, LLNL is training the next generation of stockpile stewards.

Principal Sponsorship

- DOE/NNSA. Stockpile stewardship capabilities also support DHS, DOD, DOE/IN, and U.S. intelligence agencies.

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